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Impact of Biomotor Dimensions on Efficiency of Young Judoka

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A B S T R A C T

The aim of this research was to identify factors of morphological and basic motor status in young judoka in prediction of fighting efficiency. The subject sample included 57 judoka aged 13 to 15, who have been involved in training process for averagely three years. The sample of predictor variables included a set of 18 variables for assessing anthropometric characteristics and a set of 12 variables for assessing basic motor abilities. Factor analysis was used to analyze the structure of morphological characteristics and basic motor abilities, and within the analysis, varimax rotation of principal components of the intercorrelation matrix was conducted. Morphological status of judoka was defined by four factors: longitudinal dimensionality of the skeleton, subcutaneous fat tissue, transverse dimensionality of the skeleton and body mass and volume. Motor status was defined by the following factors: power and coordination (force regulator) factor, movement frequency (speed regulator) factor, flexibility and balance factor and precision factor. Significant impact of morphological-motor factors on situational efficiency in judoka, i.e. success in competitions (multiple correlation was 0.86), was obtained by regression analysis. The best predictor of competition efficiency in young judoka was the factor which integrates explosive power, coordination and muscle endurance, and which is underlain with a force regulation mechanism. The second most important predictor determining fighting efficiency is the factor of movement frequency which is controlled by a speed regulator mechanism.

***Key words**: judo, anthropometric characteristic, motor abilities, fighting efficiency*

Introduction

Achievement of top results in judo depends on the interaction of a number of anthropological features of a judoka, his basic and specific abilities, characteristics and knowledge. It is necessary to bring anthropometric characteristics, motor and functional abilities to an optimum relation with technical performance and tactical preparation, during a direct fight with the opponent, when it is necessary to overcome the opponent in standing position or on a mat, using full psychological and physical energy potential. Therefore, the assessment and evaluation of anthropometric status of judoka and her/his specific abilities represent great significance in judo. Understanding the abovementioned also contributes to quality planning and programming of training in which the information about the real state contribute to the development of motor abilities which are closely related to specific requirements of judo[1,2]. Also, development of basic and specific motor abilities in judo enables easier and more successful mastering and refinement of a large number of technical elements and their combinations. Efficiency in a judo fight is achieved by performance of throwing (nage-waza), strangulation (shime-waza), locks (kansetsu-waza) and holding (osae-komi-waza). Such structure of movement makes judo a poly-structural acyclic activity which is characterized by a dynamic quality during the fight which occurs in aerobic-anaerobic conditions and requires judoka to have well adopted technical-tactical stereotypes which are to be applied, ability to reorganize those stereotypes and constant generation of new defensive, attacking and counterattacking programs of action[3–6]. Based on structural analysis of judo, it is logical that motor abilities of coordination and power are considered the most important ones for success in a fight. A hypothetical specification equation for judo includes power factors (explosive, maximal, repetitive, static strength), coordination factors (body coordination, performance speed of complex motor tasks, agility, reorganization of motor stereotypes), psychomotor speed

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(speed of simple movements), balance (ability to maintain and restore balance positions), flexibility (flexibility of the hip joint, and mobility of the thoracic and lumbar area of the spine), functional abilities (aerobic, anaerobic and aerobic-anaerobic), cognitive abilities (factor of perception, spatialization, memory and inductive reasoning) and conative abilities (aggressiveness, ego, superego, self-domination)[7]. For achieving successfulness on international competitions, judo athletes must achieve an excellent level of physical fitness and physical condition during training. as well as technical skill[8] Subsequently, it can be concluded that overall anthropological status is responsible for success in a judo fight, and it is therefore necessary to determine, from the scientific point of view, the size and relations of its connection to success. Katić et al. (2005)[9] explored morphological structures which determine the achievement of top results in karate. Generally, in relation to both criteria, i.e. technical and fighting efficiency, longitudinality of the skeleton and muscle mass had a positive impact, whereas fat tissue had a negative impact. Also, Katić et al. (2005)[9] pointed to the fact that top results in karate could be achieved only by those karateka who potentially had motor abilities developed above average, primarily explosive power, speed and coordination, which is especially expressed in the realization of karate kicks which are performed in combinations, namely: jaku zuki-mawashi geri and kizame zuki-jaku zuki. Precisely speed and performance quality of these techniques directly influence the efficiency of attack in karate. Blažević et al. (2006)[10] pointed to the fact that tests of specific motor abilities in karateka are greatly determined by the level of adoption of motor knowledge, and they assess specific speed (realization of kicks and blocks) and specific agility. Krstulović et al. (2005)[11] tried to determine anthropological factors which are potentially related to success in a judo fight in 15–16-year-old judoka. By discriminant analysis, it was established that successful judoka were dominant in power and functional abilities in relation to their less successful colleagues. However, there were no significant differences found in anthropometric measures. The body structure can play a determining role in the achievement of top judo performance[4,12] and also can influence on the type of techniques applied[13]. Franchini et al. (2007)[14] stated that power and endurance represented an important predictor of success in judo because judo requires a combination of power and endurance in an athlete during a fight, particularly during attempts of receiving and breaking the guard. Previous research have shown that integration of specific and basic motor abilities occurs in fighting sports in a sense of suitable integration of explosive power, speed and coordination into a general motor efficiency and/or suitable motor set which is optimal for achieving top results in each fighting sport [9,15,16,17,18]. Some research is done with the purpose of obtaining body composition, bone diameter and circumference, because of their importance for the performance among judo athletes[4,13,19]. Drid at al.(2010)[20] consider that is necessary to define basic motor skills and cognitive profiles of judokas to success in judo in judokas aged 12–14 years. They concluded that the more successful judokas generally possess better cognitive abilities, coordination and strength than less successfull ones.

The aim of this research was to identify factors of morphological and basic motor status in young judoka, which determine their success in competitions, i.e. fighting efficiency.

Materials and Methods

Study subjects

Subject sample included 57 judoka aged 13 to 15, which have been involved in the training process for averagely 3 years in 7 judo clubs: JK Dubrovnik, JK Dubrovnik 1966, JK Dalmacija Cement, JK Tempo Podstrana, JK Pujanke, JK Solin i JK Župa Dubrovačka.

Instruments

The measuring was conducted during August 2012, in Dubrovnik and Split. All athletes and their coaches were informed about the procedure and the aim of the testing, and parents gave their informed written consents for their children's participation in the testing. Croatian Judo Federation was also informed about the testing.

Sample of predictor variables included a set of 18 measures for assessing anthropometric characteristics and a set of 12 tests for assessing basic motor abilities.

A set of 18 anthropometric measures were applied according to the procedures suggested by Mišigoj-Duraković, M.[21]. A set was constructed in a way that they cover four hypothetical latent morphological dimensions[22,23]: longitudinal dimensionality of the skeleton (Body height, Arm length, Leg length, Hand length), transverse dimensionality of the skeleton (Knee diameter, Elbow diameter, Wrist diameter and Hand diameter), body voluminosity (Body weight, Upper arm circumference flexed, Upper arm circumference relaxed, Forearm circumference, Thorax circumference and Calf circumference) and subcutaneous fat tissue (Triceps skinfold, Abdominal skinfold, Back skinfold and Calf skinfold)

A set of 12 motor tests assessing explosive power (Standing long jump – for assessing explosive power of horizontal jumping, 20 meter sprint – for assessing sprinting explosive power, Throwing a 2 kg medicine ball from supine position – for assessing throwing explosive power), agility (Side steps), repetitive strength (Sit-ups), static strength (Bent arm hang), coordination (Obstacle course backwards), balance (Standing on one leg), precision (Shooting a target), flexibility (Seated straddle stretch) and movement frequency (Arm plate tapping and Foot tapping) was used to assess motor abilities.

Situational efficiency of judoka in competitions, i.e. fighting efficiency, was the criterion variable in this research. It was determined based on coaches' responses to a questionnaire, i.e., their evaluations of their athletes. The grades were ranked from 1 to 3, i.e., coaches assigned the highest grade (3) to the athlete who has won medals in Croatian championships and competitions set

by the Croatian Judo Federation. Coaches assigned grade 2 to the judeka they considered average and always a step from winning a medal in competitions mentioned. Judeka who was considered not ready to achieve success in a fight yet was evaluated by grade 1 by the coach.

Data analysis

All predictor and criterion variables underwent standard descriptive procedures to determine their basic statistics. Arithmetic mean (M), standard deviation (SD), minimum (Min) and maximum (Max) result and coefficient of asymmetry (Skewness – Skew) and peakedness of a distribution (Kurtosis – Kurt) of the results and determining MaxD value for establishing the normal distribution of variables by KS-test (KS).

Factor analysis was used to analyze the structure of morphological characteristics and basic motor abilities. Guttman-Kaiser criterion was used to extract significant principal components, and then varimax rotation of principal components of the intercorrelation matrix was conducted. In the obtained latent space, on reduced and identified factors, prediction of efficiency of judoka in competitions or fighting efficiency was conducted by regression analysis.

Results and Discussion

Analysis of descriptive statistical parameters of variables for assessing anthropometric characteristics and motor abilities indicating that all variables had normal

TABLE 1
DESCRIPTIVE STATISTICS OF VARIABLES (MORPHOLOGICAL CHARACTERISTICS AND BASIC MOTOR ABILITIES) OF JUDOKA AGED 13 TO 15

Variables	$\overline{X}$	SD	Min	Max	KS	Skew	Kurt
Body height (cm)	169.82	8.79	150.00	191.00	0.07	0.02	0.15
Arm length (cm)	72.11	3.96	64.10	83.30	0.07	0.68	0.91
Leg length (cm)	100.13	5.41	87.30	114.40	0.09	0.23	0.45
Hand length (cm)	19.88	1.19	17.40	22.90	0.06	0.23	–0.29
Knee diameter (cm)	9.68	0.58	8.60	11.00	0.08	0.12	–0.32
Elbow diameter (cm)	6.74	0.47	5.80	7.70	0.17	0.22	–0.95
Wrist diameter (cm)	5.62	0.43	4.90	6.50	0.12	0.16	–0.93
Hand diameter (cm)	7.96	0.58	5.90	9.20	0.09	–0.63	1.68
Body mass (kg)	62.54	13.23	43.10	98.00	0.11	0.69	–0.10
Upper arm circumference flexed (cm)	29.35	4.04	23.00	46.90	0.12	1.60	5.05
Upper arm circumference relaxed (cm)	26.85	3.35	20.00	36.00	0.11	0.58	0.20
Forearm circumference (cm)	25.29	2.31	22.00	33.50	0.10	1.04	1.59
Thorax circumference (cm)	85.86	8.39	70.20	106.40	0.09	0.33	–0.45
Calf circumference (cm)	34.74	3.03	30.10	44.00	0.09	0.56	–0.02
Triceps skinfold (cm)	11.95	4.50	5.33	29.00	0.11	1.38	2.96
Back skinfold (cm)	9.14	3.02	5.60	20.00	0.16	1.71	3.20
Abdominal skinfold (cm)	13.26	7.18	5.10	47.60	0.14	2.55	9.57
Calf skinfold (cm)	12.61	4.75	5.13	26.20	0.10	0.83	0.25
Standing long jump (cm)	200.75	25.52	124.00	259.00	0.08	0.02	0.68
Arm plate tapping (freq)	37.32	5.47	23.00	51.00	0.11	–0.22	0.45
20 m sprint (s)#	3.66	0.33	3.08	4.59	0.09	0.70	0.44
Side steps (s)#	9.15	1.01	7.01	10.96	0.10	–0.25	–0.59
Bent arm hang (s)	35.55	20.51	3.00	98.03	0.10	0.81	0.45
60 seconds sit-ups (freq)	53.68	10.77	33.00	80.00	0.08	0.16	–0.62
Obstacle course backwards (s)#	10.99	2.29	6.00	15.43	0.08	0.04	–0.85
Seated straddle stretch (cm)	70.96	14.50	22.00	100.00	0.08	–0.43	1.25
Foot tapping (freq)	20.58	2.44	16.00	26.00	0.13	0.13	–0.53
One leg standing (s)	10.06	9.73	1.94	44.31	0.27	1.89	2.89
Throwing a 2 kg medicine ball (m)	7.81	1.75	5.30	11.90	0.15	0.76	–0.31
Darts (score)	38.68	9.37	20.00	70.00	0.18	1.15	2.16
							K-S test = 0.18

#variable with opposite metric orientation

TABLE 2
VARIMAX FACTORS OF MORPHOLOGICAL SPACE (V) OF JUDOKA AGED 13 TO 15

Variables	V1	V2	V3	V4
Body height	0.87	–0.19	0.20	0.30
Arm length	0.81	–0.15	0.36	0.32
Leg length	0.96	–0.06	0.13	0.13
Hand length	0.64	–0.29	0.41	0.33
Knee diameter	0.27	0.15	0.76	0.29
Elbow diameter	0.36	–0.10	0.61	0.60
Wrist diameter	0.29	–0.33	0.63	0.40
Hand diameter	0.16	–0.02	0.89	0.09
Body mass	0.58	0.14	0.26	0.66
Upper arm circumference flexed	0.10	–0.04	0.08	0.80
Upper arm circumference relaxed	0.17	0.15	0.20	0.85
Forearm circumference	0.36	–0.04	0.33	0.79
Thorax circumference	0.51	0.15	0.22	0.70
Calf circumference	0.36	0.31	0.45	0.66
Triceps skinfold	–0.18	0.86	–0.11	–0.03
Back skinfold	0.07	0.79	–0.10	0.47
Abdominal skinfold	–0.09	0.84	0.02	0.22
Calf skinfold	–0.08	0.80	0.10	–0.19

TABLE 3
VARIMAX FACTORS OF BASIC MOTOR SPACE (V) IN JUDOKA AGED 13 TO 15 (N=57)

Variables	V1	V2	V3	V4
Standing long jump	0.82	0.11	0.26	0.06
Arm plate tapping	0.16	0.73	0.21	–0.07
20 m sprint from a standing start#	–0.88	0.03	0.18	0.04
Side steps#	–0.66	–0.54	0.05	–0.18
Bent arm hang	0.67	0.18	0.18	–0.23
60 seconds sit-ups	0.46	0.43	0.16	0.40
Obstacle course backwards#	–0.71	–0.16	–0.16	0.31
Seated straddle stretch	0.31	–0.26	0.77	0.02
Leg tapping	0.17	0.80	–0.13	–0.19
One leg standing	–0.04	0.37	0.75	–0.04
Throwing a 2 kg medicine ball	0.70	0.32	0.13	0.08
Darts (score)	0.13	0.16	0.04	–0.85

variable with opposite metric orientation

distribution, except for variable assessing balance and precision, was shown in Table 1. Testing the normality of distribution was conducted by Kolmogorov-Smirnov test with a critical value of 0.18.

In accordance with the aim of this research, morphological and motor status of judoka aged 13 to 15 was determined by factor analysis. Table 2 shows varimax factors of the morphological set of variables. Morphological status of judoka was defined by four factors explaining over 82% of the total variance of subjects. The first morphological factor was defined as longitudinal dimensionality of the skeleton, the second factor was defined as subcutaneous fat tissue, the third factor was defined by transverse dimensionality of the skeleton and the fourth factor was defined as body voluminosity. Four significant principal components of the correlation matrix of motor tests were extracted by Hotelling's method of principal components, according to G-K criterion. Based on principal components, 4 statistically significant factors were defined which explain 69% of total variability of subjects. Obtained factors were defined and named as followed: the first factor was named power and coordination factor and it is expressed in the integration of explosive power particularly of legs, static strength of the arms and/or muscle endurance and whole body coordination. The factor can be called a force regulator, developing due to practicing specific judo techniques by methods such as uchi komi (throwing out of balance and positioning the body in proper position), nage komi (throws) and practicing grappling (guard), relative strength is increased, as well as maximal strength, explosive power and static strength of the arms, shoulders and legs. The constant dynamic changes during a grip combat requires of judoka a combination of strength and endurance to control the distance between their opponent[14,24,25]. This is very important for adaptations of techniques and tactical skills for new attacks, defense or counter-attack actions[25]. Therefore, the ability to rapidly mobilize a strong grip and pull or push the opponent is a highly valued attribute in judo athletes[26]. Authors consider strength and endurance as potential predictors of judo performance[12,27,28].

Coordination is developed by mastering basic forms of movements on the mat (rolling, flipping, crawling), by learning to move in judo (forward, backwards, sideways), by learning throwing techniques and holding. Moreover, developed coordination enables young judoka to adopt and learn judo techniques in a quality manner. In a later phase, power and endurance come to the fore in a judo fight. The second factor named regulator of speed-movement frequency, which is emphasized in judo during swift and connected performance of techniques and their combination with the purpose of attack, defense or counterattack of the opponent. The third isolated factor can be interpreted as flexibility and balance underlain with muscle tone regulation and synergetic regulation which are of the outmost importance in judo because of their influence on the efficiency of application of particular techniques in defense and attack. For judoka, increased mobility of the hip joint and of the lumbar and thoracic area of the spine is of particular importance because greater elasticity enables better and more economic performance of specific structures of judo elements[29]. The fourth factor was interpreted as precision which is expressed through proper i.e. precise positioning of the body or parts of the body in relation to the opponent, and timely and efficient assuming of guard with the purpose of overcoming the opponent with minimal strength but with maximal efficiency, which represents one of the principles of judo. In

TABLE 4
RESULTS OF REGRESSION ANALYSIS FOR FIGHTING EFFICIENCY IN BIOMOTOR LATENT SPACE OF YOUNG JUDOKA

Factor	r	β	p
Longitudinal dimensionality of the skeleton	0.154	0.089	0.286
Subcutaneous fat tissue	–0.192	–0.141	0.182
Transverse dimensionality of the skeleton	–0.100	–0.054	0.491
Body mass and volume	0.036	0.022	0.806
Power and coordination (force regulator)	0.653	0.677	0.000
Movement frequency (speed regulator)	0.468	0.296	0.001
Flexibility and balance	–0.142	–0.080	0.326
Precision	0.130	0.070	0.366
ρ		0.856	0.000
δ		0.732	0.000

r – coefficient of correlation, β – regression coefficient, ρ – multiple correlation, δ – coefficient of determination, p – level of statistical significance

previous research it was observed that the activity of the contestants during the fight correlated with the ability to differentiate movements and speed, accuracy and precision of movement, whereas the achievement level during competition was connected with reaction time[30].

After the latent variables of morphological and motor space have been formed, regression correlation analysis was conducted between obtained morphological and motor factors as predictors and fighting efficiency as the criterion variable (Table 4).

Significant impact of morphological-motor factors on situational efficiency of judoka, or their success in competitions, was obtained by regression analysis. Multiple correlation was 0.86 which indicates that the set of predictor variables accounts for 73% of the total variance of the system (Table 4).

The best predictor of competitive efficiency of young judoka was the factor integrating explosive power, coordination and muscle endurance, which is underlain with a force regulation mechanism. Therefore, explosiveness of legs, explosive power and static strength of arms and motor coordination regulating the application of those abilities in all phases of realization are dominantly involved in realization of all judo techniques, especially of throwing techniques. Realization of the throwing technique begins with the activation of leg muscles which is underlain with leg explosiveness, and ends with the activation of arm muscles which is underlain with explosive power of arms as well as static strength of the arms and/or muscle endurance. The motor set described is the basis of motor efficiency which determines the fighting efficiency of judoka. The motor development of young judokas is a long term process, during which speed and strength abilities increase at the age 14 years[31].

The second most important predictor which determines the fighting efficiency is the factor of movement frequency which is controlled by a speed regulator mechanism. Above average psychomotor speed which is manifested through movement frequency of upper and lower extremities is necessary for efficient realization of the techniques. Technique efficiency is dependant more upon the speed of lower extremities than of the upper extremities; therefore realization speed of the beginning or the first phase of the technique is crucial for fighting success.

Other isolated motor factors do not have a significant impact on result in judo. Muscle tone regulation (flexibility) and synergetic regulation (balance) are important for motor efficiency, but these abilities are mostly inherent to force and speed factors. Also, their achieved development is satisfactory and will not be limiting the success of young athletes in judo.

Isolated morphological factors do not participate significantly in prediction of success in judo. Therefore, morphological characteristics of subjects do not deviate significantly from the optimum for achieving success in judo. It is expected that more intensive training in higher age categories would influence the integration of specific motor abilities into a morphological system and that a morphological set will be formed which will determine the success in judo.

Also, all previous research on young athletes point to the importance of determining and defining the biomotor status which is crucial in processes of selection and orientation both in judo and in other sports[32,33].

Out of the total of 8 isolated factors of morphological and motor space (4 morphological and 4 motor), force regulator which integrates power and coordination factors ($\beta = 0.68$) and speed regulator in terms of movement frequency ($\beta = 0.30$) predominately determine the situational efficiency in judo (fighting success). Development of quality in judoka is accompanied by the development of motor abilities through muscle tone regulation and synergetic regulation, psychomotor speed development and finally forming of the motor set-force regulator which integrates all factors of power (dominantly leg explosiveness) and coordination. This shows that judo sport is very complex in terms of motor abilities and in it, success is determined by development of a number of basic motor abilities, primarily of explosive power, coordination and psychomotor speed.

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UTJECAJ BIOMOTORIČKIH DIMENZIJA NA USPJEH JUDAŠA MLAĐEKADETSKOG UZRASTA

SAŽETAK

Cilj ovog istraživanja je identificirati faktore morfološkog i bazičnog motoričkog statusa judaša mlađekadetskog uzrasta u predikciji borbene efikasnosti. Uzorak ispitanika definiran je sa 57 judaša dobi od 13 do 15 godina, koji su prosječno 3 godine uključeni u trenažni proces. Uzorak prediktorskih varijabli predstavlja skup rezultata na osnovu mjerenja pomoću 18 mjera za procjenu antropometrijskih karakteristika te skup rezultata na osnovu mjerenja pomoću 12 testova za procjenu bazičnih motoričkih sposobnosti. Za analizu strukture morfoloških karakteristika i bazičnih motoričkih sposobnosti, primijenjena je faktorska analiza. Gutman-Keiserov kriterij korišten je za ekstrahiranje značajnih glavnih komponenti te je provedena varimax rotacija glavnih komponenti matrice interkorelacija. Morfološki status judaša definirala su četiri faktora: longitudinalna dimenzionalnost skeleta, potkožno masno tkivo, transverzalna dimenzionalnost skeleta i volumen i masa tijela. Motorički status je definiran faktorima: faktor snage i koordinacije (regulator sile), faktor frekvencije pokreta (regulator brzine), faktor fleksibilnosti i ravnoteže i faktor preciznosti. Regresijskom analizom dobiven je značajan utjecaj morfološko-motoričkih faktora na situacijsku uspješnost judaša, to jest uspjeha na natjecanjima (multipla korelacija iznosi 0,86). Situacijska uspješnost judaša na natjecanjima to jest borbena efikasnost određena je na temelju upitnika postavljenog trenerima odnosno na temelju ocjena koje su oni dodijelili svojim judašima. Najbolji prediktor natjecateljske efikasnosti judaša mlađekadetskog uzrasta je faktor koji integrira eksplozivnu snagu, koordinaciju i mišićnu izdržljivost i u osnovi kojeg je mehanizam za regulaciju sile. Drugi po važnosti prediktor koji determinira borbenu efikasnost je faktor frekvencije pokreta za koju je odgovoran mehanizam nazvan regulatorom brzine.